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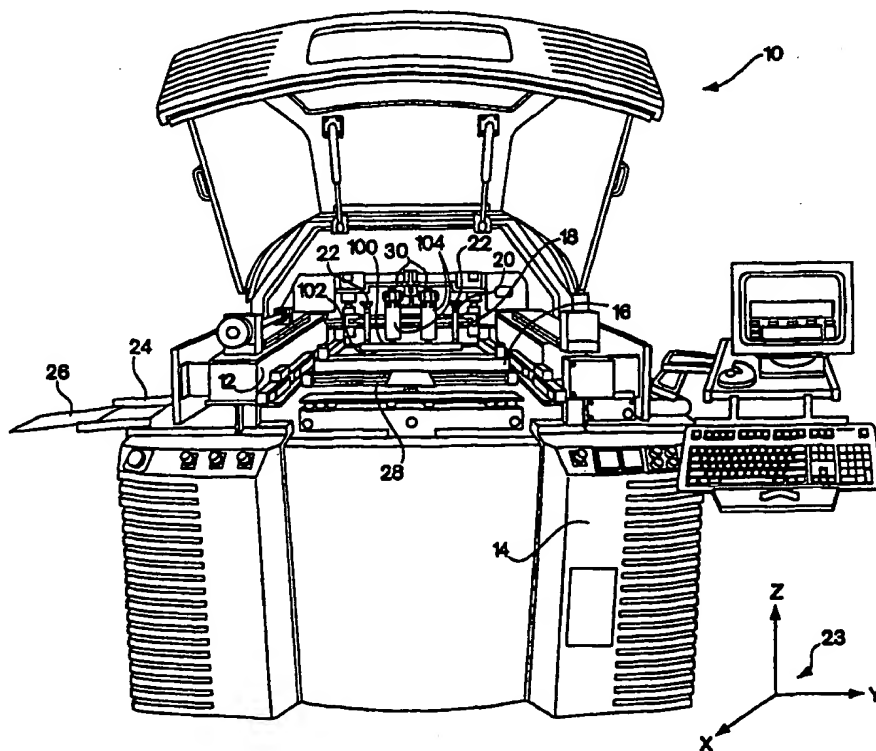
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(57) Abstract

A printer for printing a viscous material at predetermined positions forming a pattern on a substrate. The printer includes a frame, a device having a number of perforations arranged to form the pattern, a support apparatus that supports the substrate in a printing position, and a material dispenser having a substantially cylindrical chamber to contain the viscous material. The chamber has an opening through which the material is dispensed. The material dispenser is positioned over the device and constructed and arranged to dispense the viscous material through the perforations in the device onto the substrate. In embodiments of the present invention, the material dispenser is adapted to receive standard cartridges containing the viscous material, and the printer further includes a pressurized air source for forcing the viscous material from the cartridges into the material dispenser and from the material dispenser through the perforations on the device and onto the substrate.



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METHOD AND APPARATUS FOR DISPENSING MATERIALS ON A SUBSTRATE

Field of the Invention

5 The present invention relates to an apparatus and process for dispensing material, and more specifically to an apparatus and process for dispensing solder paste in a screen or stencil printer.

Background of the Invention

10 In typical surface-mount circuit board manufacturing operations, a stencil printer is used to print solder paste onto a circuit board. Typically, a circuit board having a pattern of pads or some other, usually conductive, surface onto which solder paste will be deposited is automatically fed into the stencil printer and one or more small holes or marks on the circuit board, called fiducials, is used to properly align the circuit board with the stencil or screen of the
15 stencil printer prior to the printing of solder paste onto the circuit board. In some prior art systems, an optical alignment system is used to align the circuit board with the stencil. Examples of optical alignment systems for stencil printers are described in U.S. Patent 5,060,063, issued October 21, 1991 to Freeman, and in U.S. Patent Re. 34,615, issued January 31, 1992, also to Freeman, each of which is incorporated herein by reference.

20 Once the circuit board has been properly aligned with the stencil in the printer, the circuit board is raised to the stencil, solder paste is dispensed onto the stencil, and a wiper blade (or squeegee) traverses the stencil to force the solder paste through apertures in the stencil and onto the board. As the squeegee is moved across the stencil, the solder paste tends to roll in front of the blade, which desirably causes mixing and shearing of the solder paste so as to attain desired
25 viscosity to facilitate filling of the apertures in the screen or stencil. The solder paste is typically dispensed onto the stencil from a standard cartridge such as that manufactured by SEMCO Corporation.

 In some prior art stencil printers, any excess solder paste remaining under the squeegee after it has fully traversed the stencil, remains on the stencil when the squeegee is returned to its
30 initial position for printing on a second circuit board. In some prior art screen printers, a second squeegee is used that moves across the stencil in the direction opposite to that of the first squeegee. The first squeegee and the second squeegee are used on alternating boards to continually pass the roll of solder paste over the apertures of a stencil to print each successive

circuit board. In the prior art stencil printers that utilize two squeegees, there is still the problem that at the end of a manufacturing day, or when the stencil is to be changed, excess solder paste typically remains on the stencil and must be manually removed. Also, in these prior art printers, it is difficult to maintain a desirable viscosity because volatile solvents escape from the solder paste thereby affecting the viscosity of the solder paste.

In the prior art stencil printers discussed above, the squeegee blades are typically at a predetermined angle with the stencil to apply downward pressure on the solder paste to force the solder paste through the apertures in the stencil as the squeegee is moved across the stencil. The angle of the blade is selected based on the speed at which the blade traverses the stencil and based on the desired downward pressure on the solder paste from the blade. It is desirable to maintain a consistent pressure on the solder paste as the squeegee traverses the stencil, however, in typical prior art printers, the pressure varies due to variations in paste viscosity throughout a production run, and due to variations in the angle of the squeegee caused by deformation of the squeegee due to the pressure applied by the squeegee driving device.

It is desirable to provide a method and apparatus for dispensing material onto a stencil of a printer that overcome the problems discussed above.

Summary of the Invention

Embodiments of the present invention provide methods for dispensing material and stencil printers having a dispensing apparatus that overcome the problems of the prior art discussed above.

In a first embodiment of the present invention, a printer for printing a viscous material at predetermined positions forming a pattern on a substrate is provided. The printer includes a frame, a device, mounted to the frame, having a number of perforations arranged to form the pattern, a support apparatus, coupled to the frame that supports the substrate in a printing position beneath the device, and a material dispenser having a substantially cylindrical chamber to contain viscous material to be printed on the device. The chamber has an opening through which the viscous material is dispensed. The material dispenser is coupled to a frame, positioned over the device, and constructed and arranged to dispense the viscous material through the perforations in the device and onto the substrate.

Alternate versions of the first embodiment of the present invention include a number of different features. In one version, the material dispenser is constructed and arranged to be movable along a first axis across the device while the viscous material is being dispensed from

the chamber. In another version, the chamber has a cylindrical axis extending along a length of the chamber, and the interior surface of the chamber is coated with a coating material having a low coefficient of friction to allow mixing of the viscous material within the chamber when the material dispenser is moved across the device. In alternate embodiments, different coatings
5 having both high and low coefficients of friction may be used on the interior surface of the chamber to enhance the laminar flow of material in the chamber.

In another version of the first embodiment, the printer further includes a heater to heat the viscous material or a cooler to cool the material, and the material dispenser includes at least one port to receive pressurized paste to increase the paste pressure in the chamber to force viscous
10 material from the chamber.

In yet another version of the first embodiment, the material dispenser further includes a pressure sensor that senses pressure within the chamber, and the printer further includes a controller, coupled to the pressure sensor, that senses the pressure within the chamber and maintains the pressure at a desired value.

15 In another version of the first embodiment, the material dispenser is adapted to receive a removable cartridge, and in some versions, the removable cartridge is a standard SEMCO cartridge.

In still another version of the first embodiment, the material dispenser includes a pair of inwardly facing blades with side dams that contact the device during printing to prevent excess
20 material from accumulating on the device.

In another version of the first embodiment, the printer further includes a solder gathering squeegee arm that collects excess viscous material remaining on the device when the material dispenser is lifted off of the device.

In a second embodiment of the present invention, a printer for printing a viscous material
25 at predetermined positions forming a pattern on a substrate is provided. The printer includes a frame, a device, mounted to the frame, having a number of perforations arranged to form a pattern, a support apparatus that supports the substrate in a printing position beneath the device, and a material dispenser having a chamber to contain the viscous material to be printed on the substrate. The chamber has an opening through which the viscous material is dispensed. The
30 material dispenser is positioned over the device, constructed and arranged to dispense the viscous material through the perforations in the device and onto the substrate, and adapted to receive a removable cartridge that supplies the viscous material to the chamber. The chamber has an inlet adapted to receive the viscous material from the removable cartridge.

Alternate versions of the second embodiment of the present invention may include one or more of the features of versions of the first embodiment discussed above.

A third embodiment of the present invention provides a material dispenser for dispensing a viscous material onto a stencil of a printer. The material dispenser includes a substantially
5 cylindrical chamber to contain the viscous material. The chamber has an opening through which the viscous material is dispensed. The material dispenser also includes a pair of inwardly facing blades and side dams mounted on the material dispenser in close proximity to the opening. The blades are adapted to contact the stencil during printing to prevent excess material from remaining on the device.

10 In one version of the material dispenser, an interior surface of the chamber is coated with a coating material having a low coefficient of friction to allow mixing of the viscous material within the chamber when the material dispenser is moved across the device.

Brief Description of the Drawings

15 For a better understanding of the present invention, reference is made to the drawings which are incorporated herein by reference and in which:

Fig. 1 provides a front view of a stencil printer in accordance with one embodiment of the present invention;

Fig. 2 provides a perspective view of a material dispensing head used in the stencil printer
20 of Fig. 1;

Fig. 3 provides a cross-sectional side view of the material dispensing head shown in Fig. 2;

Fig. 4 shows a close up side view of a chamber of the material dispenser of Fig. 2;

Fig. 5 shows a bottom view of the material dispenser in greater detail; and

25 Fig. 6 shows a side view of the material dispenser with a solder gathering arm.

Detailed Description

For purposes of illustration, embodiments of the present invention will now be described with reference to a stencil printer used to print solder paste onto a circuit board. One skilled in
30 the art will appreciate, however, that embodiments of the present invention are not limited to stencil printers that print solder paste onto circuit boards, but rather, may be used in other applications requiring dispensing of other viscous materials such as glues and encapsulents. Further, stencil printers in accordance with embodiments of the present invention are not limited

to those that print solder paste on circuit boards, but rather, include those used for printing other materials on a variety of substrates. Also, the terms screen and stencil may be used interchangeably herein to describe a device in a printer that defines a pattern to be printed onto a substrate.

5 Fig. 1 shows a front view of a stencil printer 10 in accordance with one embodiment of the present invention. The stencil printer 10 includes a frame 12 that supports components of the stencil printer including a controller 14, a stencil 16, and a dispensing head 100 having a dispensing slot 102 from which solder paste may be dispensed.

10 The dispensing head 100 is coupled to a first plate 18 using two thumbscrews 22. The first plate 18 is coupled to a second plate 20 which is coupled to the frame 12 of the stencil printer 10. The first plate 18 is coupled to the second plate 20 in such a manner that the first plate can be moved with respect to the second plate along a z axis, the z axis being defined by the coordinate axis system 23 shown in Fig. 1. The first plate is moved by motors under the control of the controller 14.

15 The second plate 20 is movably coupled to the frame 12 such that the second plate 20 can move with respect to the frame 12 along an x axis, the x axis also being defined by the coordinate axis system 23. As described below in further detail, the movements of the first and second plates allow the dispensing head 100 to be placed over the stencil 16 and moved across the stencil to allow printing of solder paste onto a circuit board.

20 Stencil printer 10 also includes a conveyor system having rails 24 for transporting a circuit board 26 to a printing position in the stencil printer. The stencil printer has a number of pins 28, positioned beneath the circuit board when the circuit board is in the dispensing position. The pins are used to raise the circuit board 26 off of the rails 24 to place the circuit board in contact with, or in close proximity to, the stencil 16 when printing is to occur.

25 The dispensing head 100 is configured to receive two standard SEMCO three ounce or six ounce solder paste cartridges 104 that provide solder paste to the dispensing head during a printing operation. Each of the solder paste cartridges 104 is coupled to one end of a pneumatic air hose 30. As readily understood by those skilled in the art, the dispensing head could be adapted to receive other standard, or non-standard, cartridges. The other end of each of the
30 pneumatic air hoses is attached to a compressor that under the control of the controller 14 provides pressurized air to the cartridges to force solder paste to flow from the cartridges into the dispense head 100 and onto the screen 16. Mechanical devices, such as a piston, may be used in

addition to, or in place of, air pressure to force the solder paste from the SEMCO cartridges into the dispensing head.

In one embodiment of the present invention, the controller 14 is implemented using a personal computer using the Microsoft DOS or Windows® NT operating system with application specific software to control the operation of the stencil printer as described herein.

The stencil printer 10 operates as follows. A circuit board 26 is loaded into the stencil printer using the conveyor rails 24. The dispensing head is then lowered in the z direction until it is in contact with the stencil 16. Pressurized air is provided to the cartridges 104 while the dispensing head is moved in the x direction across the stencil 16. The pressurized air forces solder paste out the cartridges and creates pressure on the solder paste in the dispensing head forcing solder paste from the dispensing slot of the dispensing head through apertures in the stencil 16 and onto the circuit board 26. Once the dispensing head 100 has fully traversed the stencil 16, the circuit board is lowered back onto the conveyor rails 24 and transported from the printer so that a second circuit board may be loaded into the printer. To print on the second circuit board, the dispensing head is moved across the stencil in the direction opposite to that used for the first circuit board. Alternatively, a squeegee arm (as described below) could swing in to contain the solder paste in the dispenser, and the dispenser can then be lifted in the z direction and moved back to its original position to prepare to print on the second circuit board using a similar direction stroke. Further description of the operation and construction of the dispensing head 100 are provided below with reference to Figs. 2-5.

The dispensing head 100 includes a housing 105 coupled to two supporting arms 106. At one end of each of the supporting arms 106 are thumbscrews 22 that provide for easy removal and installation of the dispensing head 100. The housing 105 has two ports 108 that are adapted to receive a standard SEMCO solder paste cartridge. In the illustrative embodiment described herein, the dispensing head is adapted to receive two SEMCO cartridges, however, the dispensing head may be adapted to include more or less cartridges than the two shown herein. The number of cartridges used is selected based on the length L of the dispensing head and the capacity of the cartridge used. The length L is determined in part based on the width of the circuit boards to be printed upon. If the size of the circuit board changes, then the dispensing head may be replaced by a new dispensing head having a length L sized for the new circuit boards. The effective length of the slot 102 may also be reduced to accommodate smaller circuit boards by partially covering a portion of the slot.

The housing 105 includes a cylindrical chamber 110 in which solder paste received from the SEMCO cartridges is stored prior to being dispensed onto the stencil. In one embodiment, the interior walls of the chamber 110 are coated with a material having a low coefficient of friction. Other materials, having a wide range of coefficients of friction, are used for the coating to create a desired laminar flow of solder paste in the chamber. In one embodiment, a number of different coatings having a variety of coefficients of friction may be used to create the desired laminar flow. At the slot 102, the housing has two inwardly facing blades 112 and 114. Each of the inwardly facing blades has a length approximately equal to the length L of the slot, a width equal to approximately 0.138 inches, and a thickness of approximately 0.004 to 0.010 inches.

Each of the blades 112 and 114, in one embodiment of the present invention, is made from spring steel. At each end of the blades is a side dam 103. While other materials such as plastic could be used to make the blades, the use of spring steel provides long life with continued resiliency. Each of the blades is arranged to provide an angle of approximately 15 degrees between the blade and the top surface of the stencil. Depending in part on the material used to make the blades and the speed at which the material dispenser traverses the stencil, the blades could be oriented at angles other than 15 degrees.

The dispensing head 100, in one embodiment of the present invention, further includes a pressure sensor 116 and a temperature controller 120. Incorporated within the temperature controller is a thermoelectric device and a temperature sensor. The pressure sensor 116 and the temperature controller 120 are coupled to the controller 14 through cables 118 and 122 respectively. The controller 14 is configured to measure the pressure and the temperature of the solder paste within the chamber 110 based on signals received from the sensors, and the controller controls the pressure and temperature by adjusting the force applied to the solder paste in the cartridges and by controlling the thermoelectric device contained in the temperature controller. In one embodiment, the pressure of the solder paste is maintained in the chamber by applying pressurized air at approximately 3-15 pounds per square inch to each of the cartridges 104. The temperature of the solder paste in the chamber is maintained during the printing operation at approximately 68 degrees Fahrenheit. In one embodiment, the pressure sensor is implemented using a pressure transducer with a programmable regulator and the temperature controller is implemented using a temperature probe with a thermoelectric device that can provide cooling as well as heating of the solder paste.

As discussed above, when the dispensing head is in the lowered printing position so that it is in contact with the stencil, the stencil printer 10 operates by forcing solder paste from the

dispensing head 100 onto the stencil using air pressure applied to each of the SEMCO cartridges as the dispensing head moves across the stencil. In the printing position, the blades 112 and 114 contact the top surface of the stencil. For each direction that the dispensing head moves across the stencil, one of the blades 112 and 114 will be a trailing blade and will scrape any excess solder paste off the stencil. For example, when the dispensing head 100 moves in the direction of arrow 122 in Fig. 3, blade 112 will be the trailing blade removing any excess solder paste from the stencil. The orientation of the blades and the use of a cylindrical chamber in the dispensing head causes the solder paste within the chamber 110 to roll or flow in the direction of arrow 124 when the dispensing head is moved in the direction of arrow 122. The movement of the solder paste within the chamber causes mixing and shearing of the solder paste which helps to maintain the desired temperature and viscosity of the solder paste. The coating for the internal walls of the chamber 110 allows the solder paste to move freely within the chamber.

At the conclusion of printing, when it is desired to lift the dispensing head off of the stencil, the controller 14 turns off the pressurized air source, prior to lifting the dispensing head. This causes the solder paste to remain in the chamber 110 when the dispensing head is lifted and effectively reduces the amount of solder paste that is left on the stencil when printing is complete.

To further reduce the amount of residual solder paste on the stencil, a solder gathering squeegee arm may be used to remove excess solder paste. One example of a solder gathering squeegee arm that could be used in embodiments of the present invention is described in U.S. Patent No. 5,044,306, which is incorporated herein by reference. Fig. 6 shows a solder gathering arm 130 incorporated into the dispensing head 100. The solder gathering arm includes a squeegee 131. The solder gathering arm is mounted to a bracket 132 which in turn is mounted to one or both of the supporting arms 106. The solder gathering arm is mounted to the bracket 132 using a rotatable joint 134, and the bracket 132 is movable with respect to the supporting arms 106 in the direction shown by arrow 122.

The solder gathering arm operates as follows. When the dispensing head 100 is lifted slightly off of the stencil, the bracket 132 is moved in the direction of arrow 122, and the solder gathering arm is rotated in the direction shown by arrow 136 causing the squeegee 131 to scrape along the stencil and remove any excess solder on the stencil. The rotation of the solder gathering arm and the movement of the bracket 132 is accomplished using motors or actuators under the control of the controller 14.

In embodiments of the present invention, instead of using the solder gathering arm, the blades 112 and 114 may be attached to motors or actuators that under the control of the controller cause the blades to move towards each other, scraping any excess solder paste from the screen and completely closing the slot 102. Alternatively, a pair of movable blades, in addition to
5 blades 112 and 114, may be mounted to the dispensing head and be movable towards each other to scrape excess solder paste from the stencil.

U.S. Patent Application No. 08/598,288, filed February 8, 1996, assigned in part to the assignee of the present application, and incorporated herein by reference, discloses a screen printer having a solder applicator that applies solder paste to a stencil. In one embodiment, the
10 solder applicator includes a rotatable member that mixes solder paste in the solder applicator.

Embodiments of the present invention described above may also be incorporated in a dual track stencil printer such as those described in U.S. Patent Application No. 08/802,934, filed February 21, 1997, which is incorporated herein by reference.

Embodiments of the present invention described above include standard SEMCO
15 cartridges for loading solder paste into the dispensing head. Other removable cartridges may be used in place of the SEMCO cartridges. However, it is desirable to use a standard replaceable cartridge.

The chamber of dispensing heads in embodiments of the present invention have been described as being cylindrical. The dispensing head need not be cylindrical, but rather, other
20 shapes having a substantially circular cross-section to allow rolling of the solder paste within the chamber to create a substantially laminar flow may also be used. In addition, in one embodiment, the chamber is generally kidney-shaped, and the specific shape is programmable for controlling the flow of solder paste within the chamber based on the specific solder paste material used, the speed of the dispensing head across the stencil and based on any other factors.

25 The dispensing head of embodiments of the present invention is described as being used with a stencil printer. Stencil printers such as the Ultraprint 3000 stencil printer and the AP Series stencil printer, both available from MPM Corporation of Franklin, MA, can readily be adapted for use with embodiments of the present invention.

Embodiments of the present invention overcome problems associated with prior art
30 stencil printers by providing dispensing heads and stencil printers that effectively remove excess solder paste from the stencil. In addition, the pressure applied to the solder paste to force it through apertures in the stencil is precisely controlled using a closed loop feedback system.

Having thus described at least one illustrative embodiment of the invention, various alterations, modifications and improvements will readily occur to those skilled in the art. Such alterations, modifications and improvements are intended to be within the scope and spirit of the invention. Accordingly, the foregoing description is by way of example only and is not intended
5 as limiting. The invention's limit is defined only in the following claims and the equivalents thereto.

CLAIMS

1. A printer for printing a viscous material at predetermined positions forming a pattern on a substrate, the printer comprising:

a frame;

5 a device, mounted to the frame, having a number of perforations arranged to form the pattern;

a support apparatus, coupled to the frame, that supports the substrate in a printing position beneath the device; and

10 a material dispenser having a substantially cylindrical chamber to contain the viscous material to be printed on the substrate, the chamber having an opening through which the viscous material is dispensed, the material dispenser being coupled to the frame, positioned over the device, and constructed and arranged to dispense the viscous material through the perforations in the device and onto the substrate.

15 2. The printer of claim 1, wherein the material dispenser is constructed and arranged to be movable along a first axis across the device while the viscous material is being dispensed from the chamber.

20 3. The printer of claim 2, wherein the chamber has a cylindrical axis extending along a length of the chamber, and wherein the cylindrical axis is orthogonal to the first axis.

4. The printer of claim 3, wherein an interior surface of the chamber is coated with a coating material having a low coefficient of friction to allow mixing of the viscous material within the chamber when the material dispenser is moved across the device.

25 5. The printer of claim 4, further comprising a temperature controller, coupled to the material dispenser, to modify temperature of the viscous material within the dispenser.

30 6. The printer of claim 5, wherein the material dispenser includes at least one port to receive pressurized air to provide air pressure to the chamber to force the viscous material from the chamber.

7. The printer of claim 6, wherein the material dispenser includes a pressure sensor to sense pressure within the chamber, and wherein the printer further comprises a controller coupled to the pressure sensor that senses the pressure within the chamber and controls the pressurized air provided through the port to maintain the pressure within the chamber at a desired value.

8. The printer of claim 7, wherein the material dispenser includes a temperature sensor to sense temperature of the viscous material within the chamber, and wherein the controller controls the temperature controller to maintain the temperature at a desired value.

9. The printer of claim 8, wherein the material dispenser is adapted to receive a removable cartridge that supplies the viscous material to the chamber, the chamber having an inlet to receive the viscous material from the removable cartridge.

10. The printer of claim 9, wherein the pressurized air is provide to the cartridge to force the viscous material from the cartridge into the chamber.

11. The printer of claim 10, wherein the material dispenser is adapted to receive at least one removable cartridges.

12. The printer of claim 11, wherein the opening of the chamber is elongated about an axis that is parallel to the cylindrical axis.

13. The printer of claim 12, wherein the material dispenser further includes a pair of inwardly facing blades that contact the device during printing to prevent excess material from remaining on the device.

14. The printer of claim 13, wherein each of the blades is made from spring steel.

15. The printer of claim 14, wherein the viscous material is solder paste and the device is a stencil for printing solder paste on a circuit board.

16. The printer of claim 15, wherein the material dispenser is movable in a vertical direction to allow the material dispenser to be lifted off of the device.

17. The printer of claim 16, further comprising a material gathering arm that collects
5 excess viscous material remaining on the device when the material dispenser is lifted off of the device.

18. The printer of claim 1, further comprising a heater, coupled to the material dispenser, to heat the viscous material within the dispenser.

10

19. The printer of claim 18, wherein the material dispenser includes a temperature sensor to sense temperature of the viscous material within the chamber, and wherein the printer further comprises a controller that controls the heater to maintain the temperature at a desired value.

15

20. The printer of claim 1, wherein the material dispenser includes at least one port to receive pressurized air to provide air pressure to the chamber to force the viscous material from the chamber.

20

21. The printer of claim 20, wherein the material dispenser includes a pressure sensor to sense pressure within the chamber, and wherein the printer further comprises a controller coupled to the pressure sensor that senses the pressure within the chamber and controls the pressurized air provided through the port to maintain the pressure within the chamber at a desired value.

25

22. The printer of claim 8, wherein the material dispenser is adapted to receive a removable cartridge that supplies the viscous material to the chamber, the chamber having an inlet to receive the viscous material from the removable cartridge.

30

23. The printer of claim 22, wherein the pressurized air is provide to the cartridge to force the viscous material from the cartridge into the chamber.

24. The printer of claim 23, wherein the material dispenser is adapted to receive at least one removable cartridge.

25. The printer of claim 1, wherein the opening of the chamber is elongated about an axis that is parallel to the cylindrical axis, and wherein the material dispenser further includes a pair of inwardly facing blades that contact the device during printing to prevent excess material from remaining on the device.

26. The printer of claim 25, wherein each of the blades is made from spring steel.

27. The printer of claim 1, wherein the material dispenser is movable in a vertical direction to allow the material dispenser to be lifted off of the device, and wherein the printer further comprises a wiping squeegee and a material gathering head that collect excess viscous material remaining on the device when the material dispenser is lifted off of the device.

28. A printer for printing a viscous material at predetermined positions forming a pattern on a substrate, the printer comprising:

a frame;

a device, mounted to the frame, having a number of perforations arranged to form the pattern;

a support apparatus, coupled to the frame, that supports the substrate in a printing position beneath the device; and

a material dispenser having a chamber to contain the viscous material to be printed on the substrate, the chamber having an opening through which the viscous material is dispensed, the material dispenser being coupled to the frame, positioned over the device, constructed and arranged to dispense the viscous material through the perforations in the device and onto the substrate, and adapted to receive a removable cartridge that supplies the viscous material to the chamber, the chamber having an inlet to receive the viscous material from the removable cartridge.

29. The printer of claim 28, wherein the printer is adapted to provide pressurized air to the cartridge to force viscous material from the cartridge into the chamber and from the chamber through the perforations in the device and onto the substrate.

30. The printer of claim 30, wherein the material dispenser includes a pressure sensor to sense pressure within the chamber, and wherein the printer further comprises a controller coupled to the pressure sensor that senses the pressure within the chamber and controls the pressurized air to maintain the pressure within the chamber at a desired value.

5

31. The printer of claim 28, further comprising a heater, coupled to the material dispenser, to heat the viscous material within the dispenser.

32. The printer of claim 31, wherein the material dispenser includes a temperature
10 sensor to sense temperature of the viscous material within the chamber, and wherein the printer further comprises a controller that controls the heater to maintain the temperature at a desired value.

33. The printer of claim 28, wherein the material dispenser further includes a pair of
15 inwardly facing blades that contact the device during printing to prevent excess material from remaining on the device.

34. The printer of claim 33, wherein each of the blades is made from spring steel.

20 35. The printer of claim 28, wherein the viscous material is solder paste and the device is a stencil for printing solder paste on a circuit board.

36. The printer of claim 28, wherein the material dispenser is movable in a vertical direction to allow the material dispenser to be lifted off of the device, and wherein the printer
25 further comprises a material gathering arm that collects excess viscous material remaining on the device when the material dispenser is lifted off of the device.

37. A material dispenser for dispensing a viscous material onto a stencil of a printer, the material dispenser comprising:

30 a substantially cylindrical chamber to contain the viscous material, the chamber having an opening through which the material is dispensed;

a pair of inwardly facing blades mounted on the material dispenser in close proximity to the opening, the blades being adapted to contact the stencil during printing to prevent excess material from remaining on the device.

- 5 38. The material dispenser of claim 37, wherein an interior surface of the chamber is coated with a coating material having a low coefficient of friction to allow mixing of the viscous material within the chamber when the material dispenser is moved across the device.

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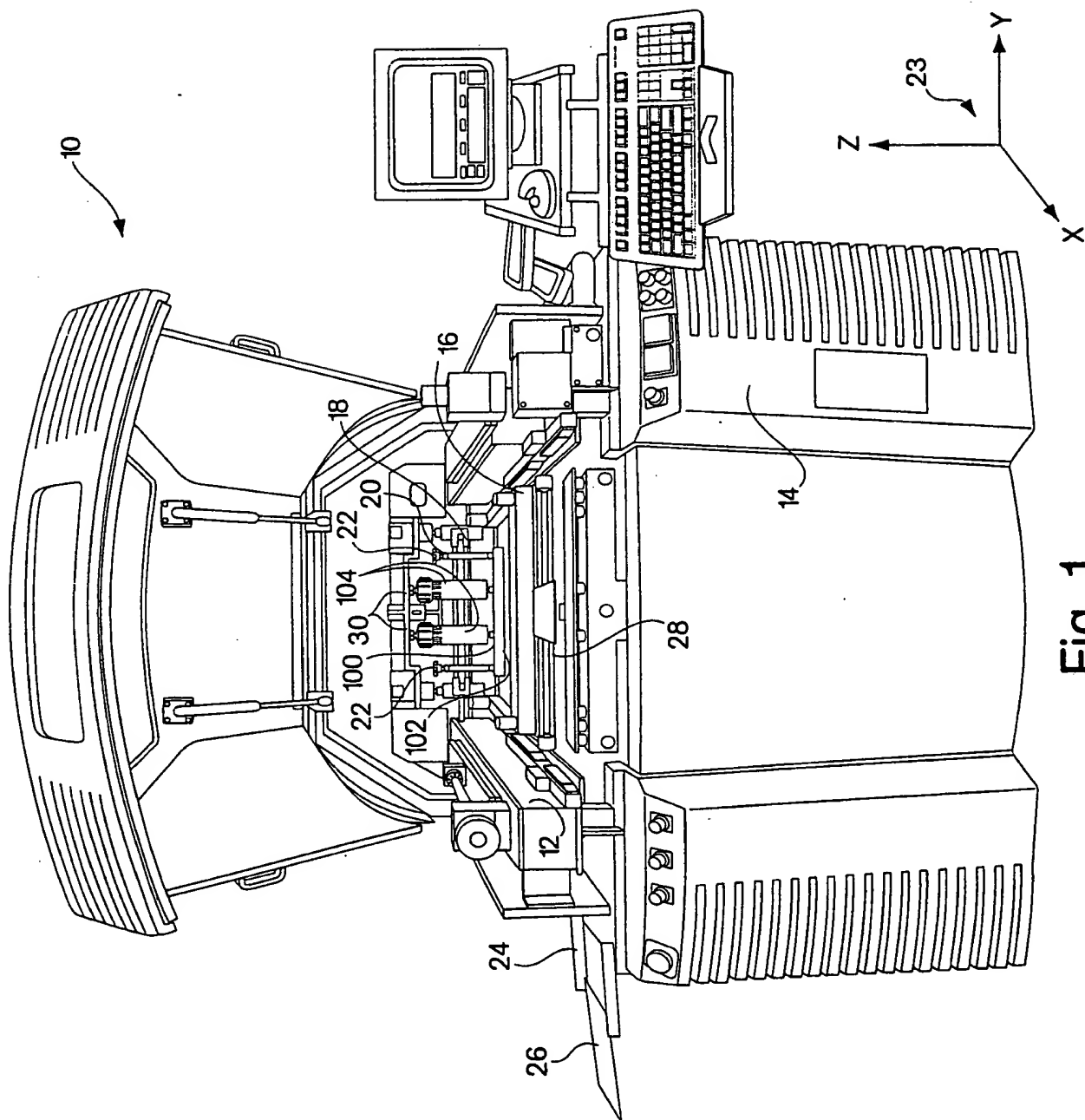


Fig. 1

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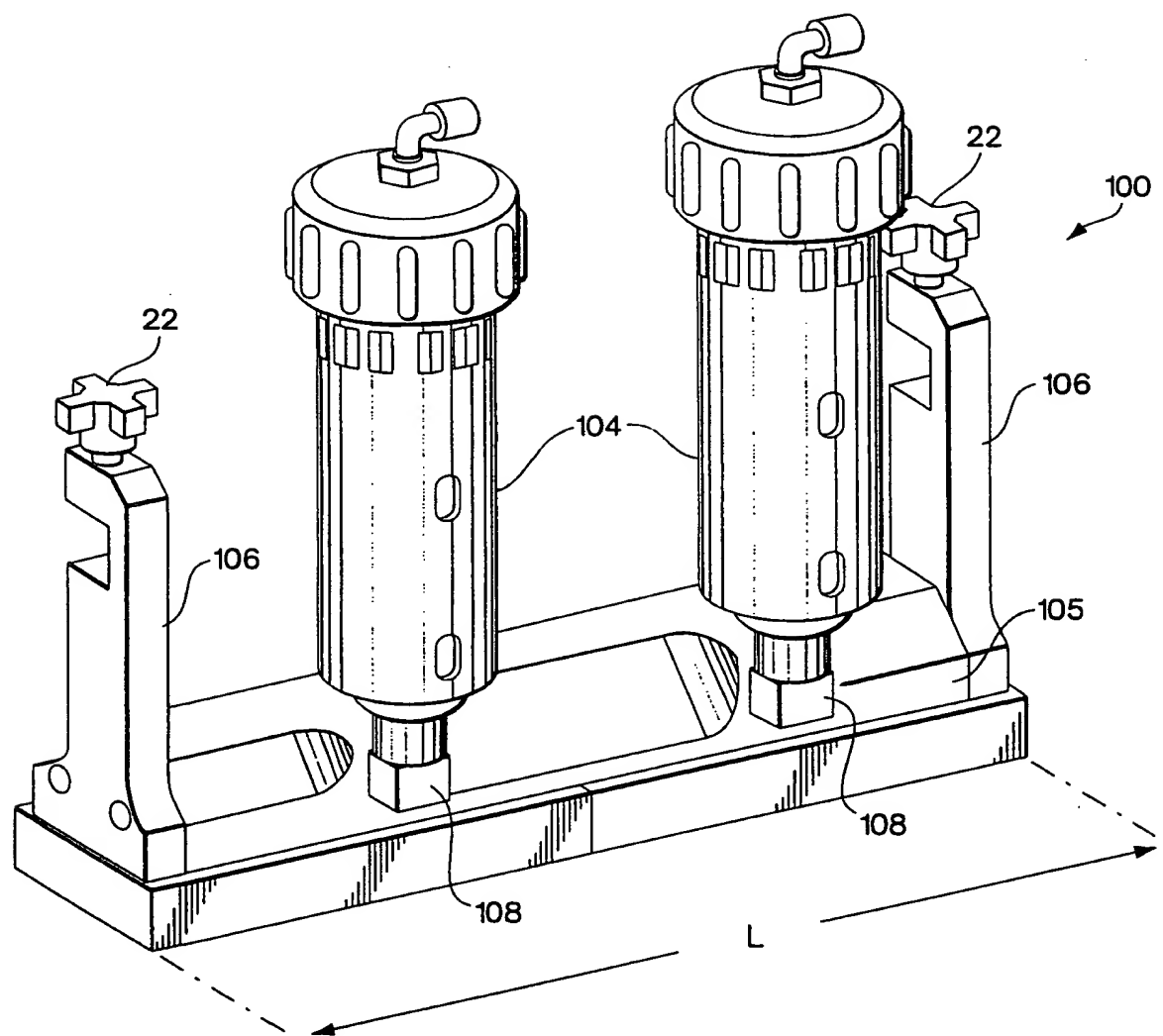


Fig. 2

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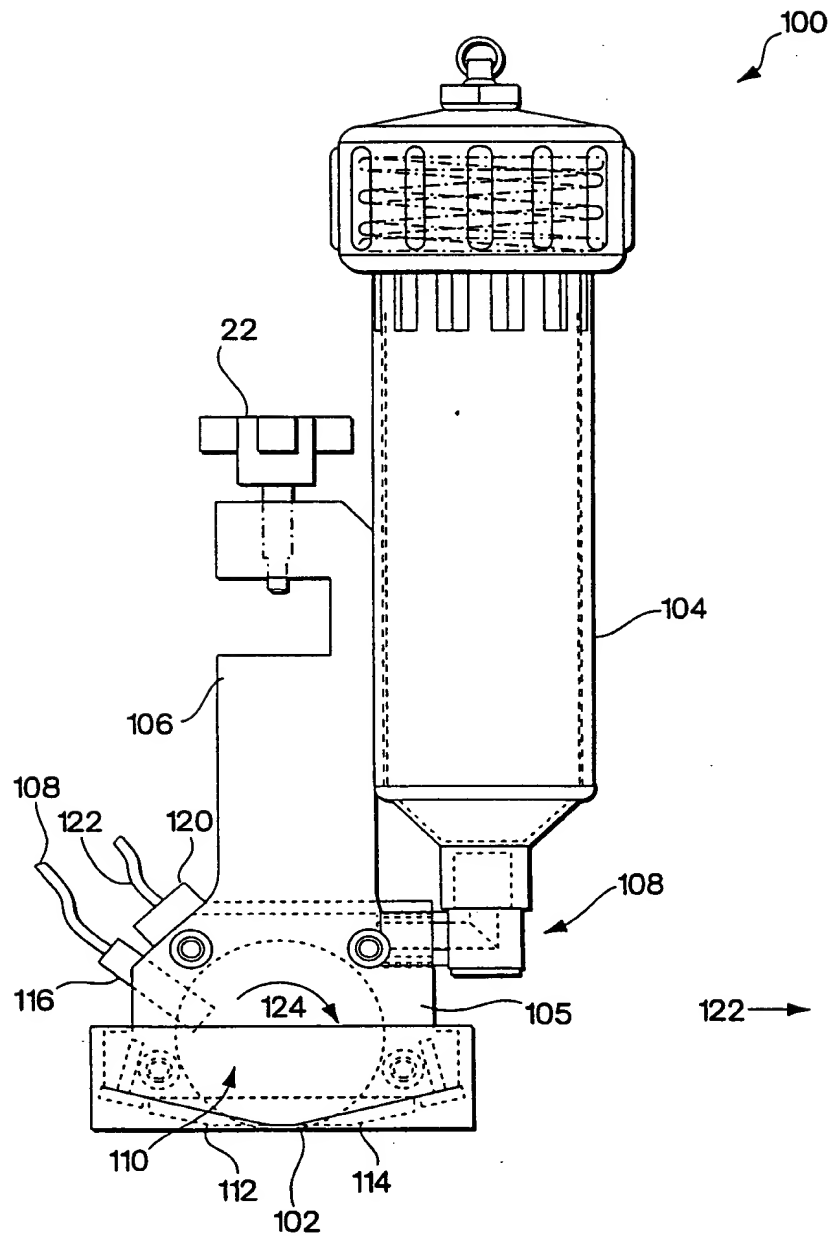


Fig. 3

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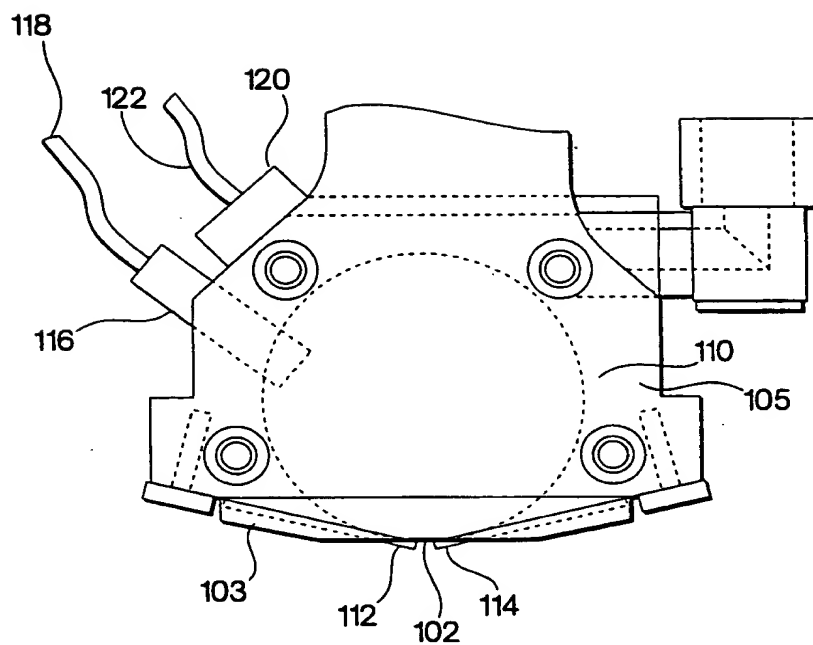


Fig. 4

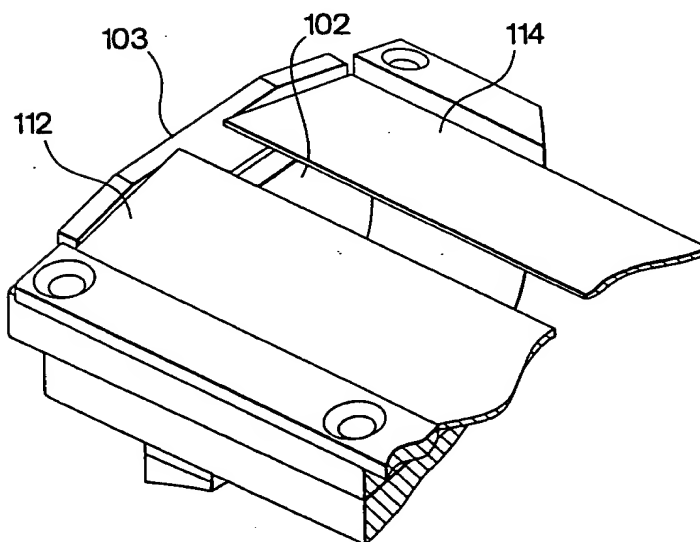


Fig. 5

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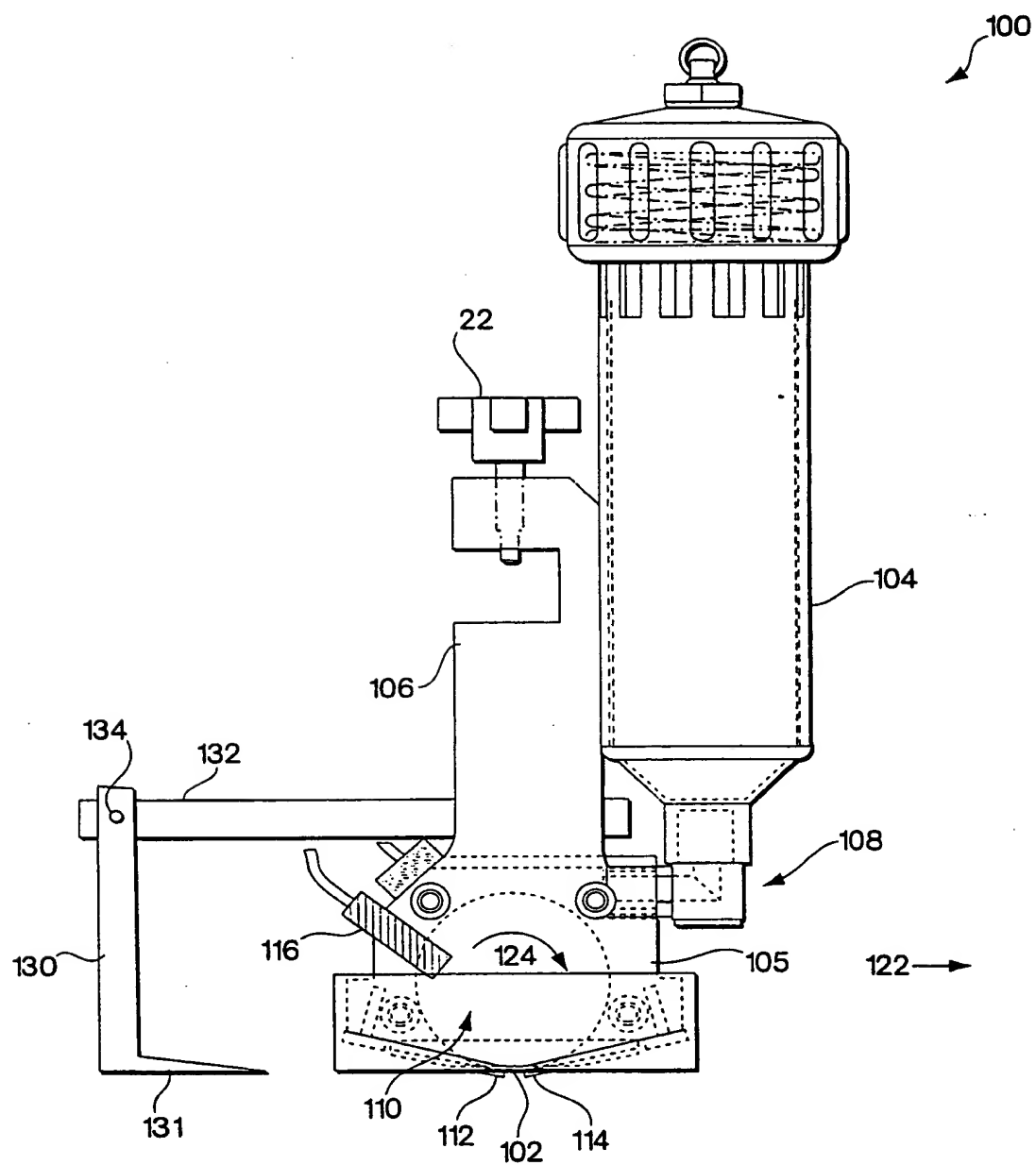


Fig. 6

INTERNATIONAL SEARCH REPORT

Internat Application No

PCT/US 98/23089

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B23K3/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 598 182 A (ASYMPTOTIC TECHNOLOGIES, INC.) 25 May 1994	1, 2, 18-24, 28-32 3-11
Y	abstract see column 5, paragraph 1; figures 1, 6 see column 5, paragraph 3 see column 7, paragraph 1 see column 8, paragraph 4 - paragraph 5 ---	
Y	US 5 364 011 A (BAKER ET AL.) 15 November 1994 see column 3, line 36 - line 48; figure 1 see column 5, line 49 - line 53 see column 5, last paragraph see column 4, line 5 - line 20 --- -/--	3-11

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

24 February 1999

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International Application No

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 149 (M-694) '2996!, 10 May 1988 & JP 62 270272 A (SHIGENAGA NAGATA), 24 November 1987 see abstract	13,14
A	DE 195 41 996 A (FINN, DAVID) 15 May 1997 abstract see figures 1,2	1-3,28

INTERNATIONAL SEARCH REPORT

Information on patent family members

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